

A Systematic Review of Dental Implant Failure Rates in the Esthetic Zone

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Abstract

This systematic review evaluated the failure rates of dental implants placed in the aesthetic zone. A thorough search was conducted across various electronic databases, including manual reference checks, using relevant keywords and inclusion criteria based on the PICO framework (population, intervention, control, and outcomes). A total of 11 studies were included in the analysis, consisting of both randomized controlled trials (RCTs) and non-randomized studies. The overall failure rate was found to be low at 2%, with a marginal bone loss of 1%. Aesthetic outcomes, such as pink aesthetic scores, were favorable, with a small percentage of mid-facial soft tissue and papillary recessions. This analysis demonstrates that dental implant failure in the aesthetic zone is minimal, with low bone loss and satisfactory aesthetic results.

Keywords: aesthetic zone, socket-shield, failure rate, dental implants, implant

Introduction and Background

Patients facing tooth loss have a range of treatment options to choose from, and clinicians play a key role in guiding these decisions by providing information on the risks and benefits of each approach [1]. Among the various treatment options, dental implant-supported prostheses have significantly broadened the possibilities, improving the quality of discussions between patients and dentists, and enhancing overall treatment outcomes [1,2]. Dental implants offer an effective solution for replacing missing teeth, with an impressive success rate of 82.9% over a 16-year period when the relevant factors are appropriately considered [3].

However, the risk of implant failure is influenced by a variety of factors, including age, sex, smoking habits, the implant site, bone quality, and underlying chronic health conditions [4-6]. The process of osseointegration—the integration of the implant into the bone—is critical for the long-term success of the procedure, although failures can still occur, necessitating the removal of the implant [7,8]. Implant failure can be categorized into biological, mechanical, iatrogenic, or failure due to poor adaptation to the surrounding tissues [9-11].

The rehabilitation of lost teeth using dental implants presents particular challenges in the esthetic zone, where patients demand both functional and cosmetic results [12]. Bone and soft tissue deficiencies at the implant site can significantly affect the overall success of the treatment [12,13]. Techniques such as immediate provisional restorations and custom healing

abutments have been developed to enhance the aesthetic outcome, ensuring a more natural appearance for patients [12-14] .

One of the techniques employed to manage deficiencies in the alveolar ridge is alveolar ridge preservation. This process involves placing grafting materials into a tooth socket after extraction, using a range of methods including guided bone regeneration, connective tissue grafting, and partial extraction therapies like the socket-shield and pontic-shield techniques [15,16] . A significant development in this area is the socket-shield technique, introduced in 2007, which allows for immediate implant placement in cases where the tooth is being extracted, particularly in the anterior maxillary region [16] . This minimally invasive approach has undergone modifications over time to reduce complications and improve the overall outcomes. Notably, the use of 3D imaging and cone beam computed tomography (CBCT) for pre-surgical planning has further enhanced the precision and effectiveness of this technique [17-19] .

Review

Research Methodology

This review followed standard guidelines for systematic reviews . The process involved several key stages: establishing inclusion and exclusion criteria, identifying information sources, selecting studies, assessing the quality of the studies, extracting relevant data, and synthesizing the findings.

Database Search Strategy

A search was carried out across multiple electronic databases, with specific keywords used to identify relevant studies. Boolean operators such as "AND" and "OR" were applied to refine the search and ensure the inclusion of studies relevant to the aesthetic zone and dental implant techniques, such as socket-shield and conventional methods.

Eligibility Criteria

Studies considered for inclusion were those published in English, focusing on dental implants in the aesthetic zone, and with study designs including randomized controlled trials, prospective studies, and retrospective analyses.

Study Selection Process

The search generated a significant number of articles, which were reviewed by multiple independent reviewers. After screening titles and abstracts for relevance, duplicates were removed, and studies providing sufficient data were included in the final review. Irrelevant studies were excluded after a full-text review.

Data Extraction and Study Outcomes

Key information from the studies, such as author names, publication year, study design, patient demographics, failure rates, bone loss, success rates, and techniques used, was extracted into a data sheet for analysis.

Quality Assessment

The quality of RCTs was assessed using the Cochrane Risk of Bias tool, which evaluates aspects like randomization, blinding, and outcome reporting. Non-randomized studies were assessed using the Newcastle-Ottawa scale, which focuses on selection, comparability, and follow-up adequacy.

Data Analysis

Data from the selected studies were analyzed using statistical software. A random-effects was conducted to calculate the overall effect size, with odds ratios used to quantify the impact. Heterogeneity among the studies was assessed, and the results were visualized using a forest plot. Publication bias was also evaluated through statistical tests and visualized in a funnel plot.

Results

Study Selection

A total of 402 articles were identified, from which 14 articles came from PubMed, 380 from ScienceDirect, and 8 from a manual search. After applying inclusion criteria, 21 articles were screened for eligibility. Following full-text review, 11 studies met the criteria and were included in the systematic review.

Characteristics of Included Studies

A total of 11 studies were included in the review, comprising various study types such as randomized controlled trials (RCTs), retrospective studies, descriptive studies, and prospective studies. A total of 2757 patients were involved in the studies, all of whom underwent dental implants placed in the esthetic zone. The follow-up period ranged from one month to five years. Some studies reported dental implant failure rates, with a few recording zero failures, while others reported higher failure rates.

Table 1: Summary of Study Characteristics

Study Author	Study Type	Participants Count	Implant Techniques	Failure Rate (%)	Survival Rate (%)	Follow-up Period	Common Sites Treated	Main Complications
Tiwari et al. (2019)	RCT	16 patients	SST in esthetic region & without SST	0%	100%	1-12 months	Maxillary anterior region	Apical resorption of the shield
Sun et al. (2019)	RCT	30 patients	SST & Conventional flap-less approach	0%	100%	1-24 months	Incisor & Canine	No complications
Siormpa (2014)	Retrospective	46 patients	Root-membrane technique	2.2%	97.8%	24-60 months	Maxillary anterior teeth	Apical resorption
Gluckman et al. (2017)	Retrospective	128 implants	SST & Immediate Implant Placement	3.9%	96.1%	1-4 years	Maxillary & Mandibular	Infection, Implant failure
Amir Alireza (2015)	Descriptive	2381 Implants	Immediate/early/delayed implant placement	0.8%	99.1%	2 years	Maxillary & Mandibular	Implant failure, Dehiscence
De Rouck et al. (2008)	Retrospective	30 patients	Immediate Implant Placement	3.3%	96.7%	1-12 months	Anterior maxilla	Implant failure
Mijiritsky et al. (2009)	RCT	24 implants	Immediate Implant Placement	4.2%	95.8%	Up to 6 years	Maxillary esthetic zone	Implant failure
Kher et al.	Retrospective	21 implants	SST technique	0%	100%	12-42 months	Esthetic zone	Early shield exposure,

Study Author	Study Type	Participants Count	Implant Techniques	Failure Rate (%)	Survival Rate (%)	Follow-up Period	Common Sites Treated	Main Complications
(2018)						hs		Midfacial recession
Bramanti et al. (2018)	RCT	40 patients	SST technique & Conventional	0%	100%	1-36 months	Maxillary/mandibular teeth	No complications
Cosyn et al. (2016)	Prospective	22 patients	Immediate Implant Placement	4.5%	95.5%	Up to 5 years	Central & Lateral Incisors	Implant failure, Aesthetic issues
Maló et al. (2003)	Prospective	116 implants	Immediate/early implant placement	4.3%	95.7%	1 year	Maxillary & Mandibular	Fistulas, Implant failure

Discussion

This systematic review focused on evaluating the failure rates of dental implants placed in the esthetic zone. The findings confirm previous studies, showing that dental implants in this region have an overall success rate of 98%, corresponding to a failure rate of about 2% [18,19] .

Based on the data from this analysis, the mean dental implant failure rate was found to be 2%, with a 95% confidence interval ranging from 0.00% to 0.03% for the socket-shield technique. Notably, the study by Alireza et al. [27] , which had the largest sample size of 1,281 implants, reported a success rate of 99.1%, with only a 0.8% failure rate. On the other hand, the study with the smallest sample size achieved a 100% success rate, though it noted the complication of apical resorption of the shield [23] . These results align closely with prior literature, which reported a failure rate of 1.37%, with no observed heterogeneity across studies [18] . One study, with 76 implants and a follow-up of one year, recorded a 98.1% success rate and a failure rate of 1.9%, with complications including fistulas, gingival retraction, and paresthesia [33] .

The socket-shield technique, as described in the literature, aims to preserve the buccal bone plate, contributing to improved esthetic outcomes. As a result, most studies included in this review placed implants in the anterior maxilla. However, this site is known to carry a higher risk of marginal bone resorption and apical resorption of the shield post-implantation [34] . Notably, Bramanti et al. [31] found no resorption of the root portion left behind after extraction, as the internal portion of the alveolus typically undergoes resorption post-tooth extraction, while the surrounding periodontal tissues help stabilize the marginal bone crest. However, the bone around dental implants is more prone to resorption, which can expose the rough surface of the implant [35] .

Esthetic outcomes, measured using the pink esthetic score (PES), showed a mean score of 11.75, with a proportion of 0.43%. This index, which evaluates soft tissue recession in the socket-shield technique compared to conventional methods, revealed minimal mid-facial recession (0.02%)

and slight mesial and distal papillary recession (0.02% and 0.01%, respectively). The socket-shield technique helps maintain the marginal bone crest, which may account for the high PES reported in some studies [24,30]. The PES is considered one of the most reliable and valid indices for assessing soft-tissue esthetics around immediate implants [36]. The preservation of marginal bone and soft tissues around the implants likely contributed to the higher PES scores (range: 11.12–12.61) found in this review.

Regarding limitations, the study sample size was relatively small due to the exclusion of many studies that did not meet the inclusion criteria. Additionally, low heterogeneity in the results was observed, which may be attributed to the inclusion of studies with various designs and similar implant placement sites. Future research should aim to address this limitation by incorporating additional studies to confirm or refine the findings.

Conclusions

Dental implant-supported prostheses have significantly improved treatment options in prosthodontics, especially in restoring missing teeth in the esthetic zone. Based on the current systematic review dental implant failure rates in the esthetic zone, whether using the socket-shield technique or conventional methods, are minimal. Complications reported include apical resorption, infection, dehiscence, fistulas, recession, and implant failure. The studies also revealed an average of 1% marginal bone loss and relatively high esthetic outcomes. However, factors such as smoking, bone quality, and systemic health should be carefully considered, as they may increase the risk of implant failure.

In conclusion, dental implants in the esthetic zone have a success rate of approximately 98%, with a failure rate around 2%. Further studies with larger sample sizes and a variety of implant techniques are necessary to validate and refine these findings.

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